K. Chandrasekhara NAIDU*: A contribution to the embryology of *Begonia sulcata* and *B. rex* 'President'

K. C. ナイヅ*: *Begonia sulcata* と *B. rex* 'President' の胚発生

The genus *Begonia*, a member of Begoniaceae, is widely cultivated throughout the globe for its colourful foliage and flowers. Although the genus comprises 900 species, very little work has been done on its embryology (Sandt 1921, Souèges 1939, Madulata 1950, Swamy & Parameswaran 1960, Devi & Naidu 1979, 1982, Devi *et al.* 1982, Naidu 1981, 1985, Naidu & Devi 1984). It was, therefore, proposed to study the embryology of the two species, *Begonia sulcata* Scheidw and *Begonia rex* 'President' cultivar.

Materials and methods The materials for the present investigation were collected from Lal Baugh Garden, Bangalore and fixed in formalin-acetic-alcohol. Customary methods were followed during dehydration and embedding (Johansen 1940). Sections were cut at a thickness of 4-10 microns and stained in Delafield's haematoxylin.

Observations Microsporangium, microsporogenesis and male gametophyte. The hypodermal archesporium in transection consists of three cells (Fig. 1, A). Although development of the anther wall corresponds to the dicotyledonous type due to periclinal division in the middle layer, two layers are formed (Fig. 1, B, C). The tapetum is of the secretory type and is uniseriate with uninucleate cells (Fig. 1, D), which later due to mitotic divisions contain 2 or 3 nuclei (Fig. 1, F, G). In the later stages the cells of middle layer degenerate and the endothecium acquires fibrillar thickenings (Fig. 1, E). The microspore mother cells, after the usual reduction divisions, give rise to tetrahedral, decussate and isobilateral tetrads (Fig. 1, H-J). At shedding stage the pollen grains are 2-celled and tricolpate with smooth and thick exine with a thin hyaline intine (Fig. 1, L-N). Rarely, pollen grains with three or four nuclei are observed in *B. sulcata* (Fig. 1, O, P). In both the cases degeneration of anther and pollen at different stages of development is quite common. Usually, one, two or three microspores in each tetrad become abortive and as a result only a few microspores remain

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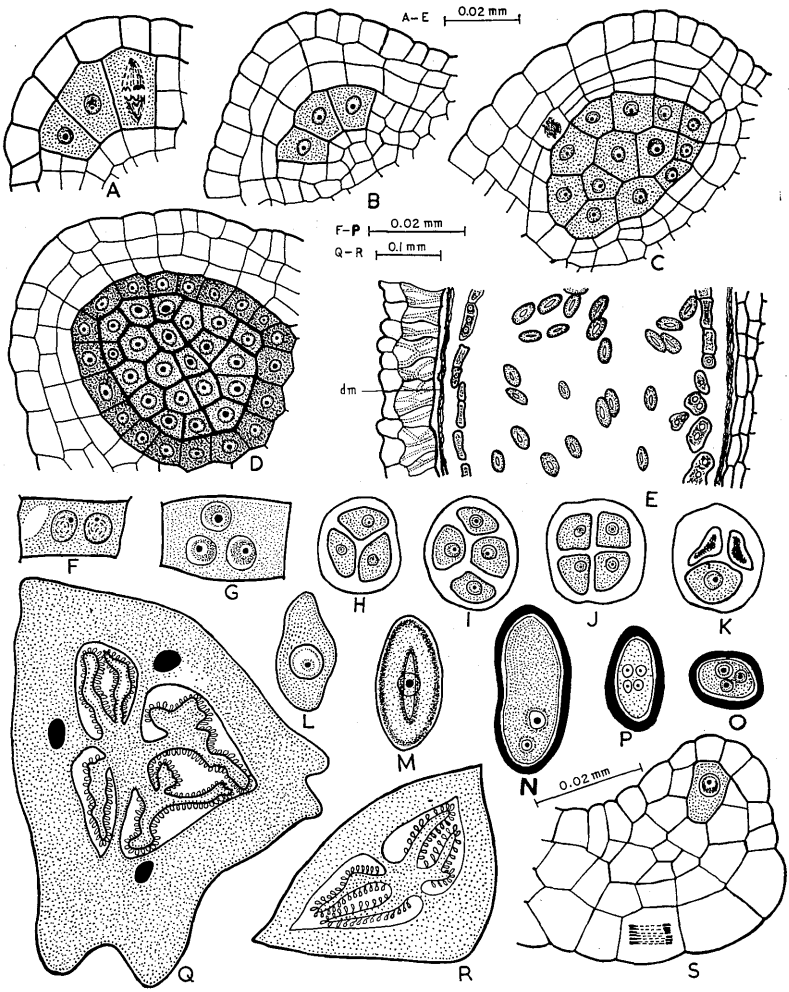

Fig. 1. *Begonia sulcata* (A, B, D, I, K, O, P, R) and *Begonia rex* 'President' (C, E, F–H, J, L–N, Q, S). A–D: Transverse sections of anther lobes showing anther wall development and sporogenous tissue. E: Longitudinal section of anther lobe showing epidermis, fibrous endothecium with degenerating middle layers and tapetum. F, G: Two- and three-nucleate tapetal cells. H–J: Pollen tetrads. K: Pollen tetrad with degenerating pollen grains. L–P: Pollen grains. Q, R: Transverse sections of ovaries. S: Longitudinal section of ovule showing single-celled archesporium. dm: degenerating middle layers.

fertile (Fig. 1, K).

Ovary, ovule, megasporogenesis and female gametophyte. The winged inferior ovary is bi- or tricarpellary syncarpous and bi- or trilocular. The projecting axile placentae are bifurcated or sometimes variously branched and bear numerous ovules (Fig. 1, Q, R). Ovular primordia develop in large numbers from the placentae and give rise to anatropous, bitegmic and weakly crassinucellate ovules. The integument initial becomes differentiated soon after the archesporial cell is developed in the ovular primordium (Fig. 1, S). The outer integument outgrows the inner and consists of two or three layers of cells of which the outer epidermis consists of larger cells (Fig. 2, A). The inner integument which is made up of two layers of small cells develops slowly and reaches up to tip of the nucellus (Fig. 2, A).

The hypodermal archesporium is single-celled (Fig. 1, S). It cuts off an outer primary parietal cell and an inner megaspore mother cell. The primary parietal cell undergoes anticlinal divisions to produce a layer of parietal cells (Fig. 2, A). The megaspore mother cell undergoes meiosis and produces either linear or T-shaped megaspore tetrads (Fig. 2, B, C). The development of the female gametophyte is of the Polygonum type (Fig. 2, B, C, F, G, I). However, as a rare feature in *B. sulcata*, Allium type of embryo sac development is also observed besides Polygonum type (Fig. 2, D, E, H). The synergids are pear-shaped. The uninucleate antipodals are three in number and are ephemeral.

With the differentiation and growth of the megaspore mother cell, the nucellus becomes disorganised except a few parietal cells at the micropylar end. Thus, very soon, the embryo sac comes to lie in contact with the inner layer of the inner integument (Fig. 2, B, C). Then the cells of the inner layer of inner integument elongate radially, accumulate abundant cytoplasm and differentiate into the endothelium (Fig. 2, B, C, H, I). Simultaneously with the development of endothelium, the cells at the level of origin of the two integuments and directly below the embryo sac become thin-walled, elongated longitudinally and differentiate into hypostase (Fig. 2, H, I). Abnormal behaviour of endothelium and hypostase is common in majority of ovules of each species causing embryo sac and ovule degeneration. Thus 90% of the ovules in *B. sulcata* completely become degenerated at an eight-nucleate embryo sac stage (Fig. 2, J).

Fertilization and endosperm. The path of pollen tube is porogamous. The actual process of syngamy and triple fusion could not be traced.

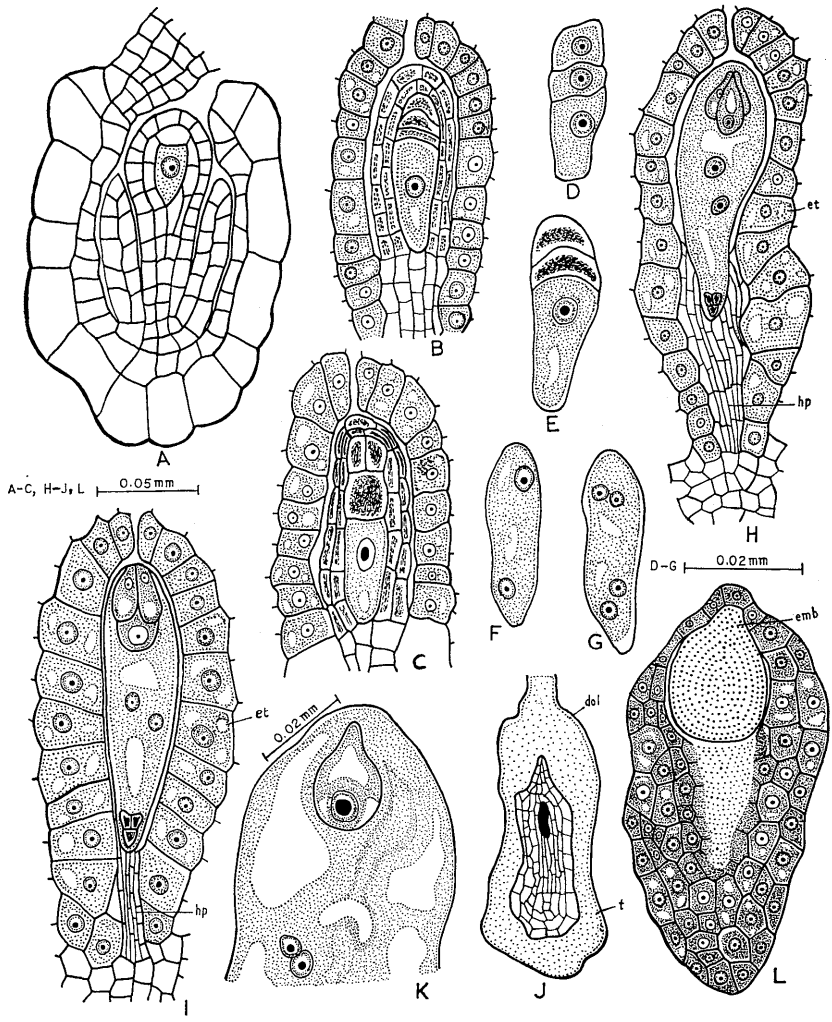

Fig. 2. *Begonia sulcata* (C–H, J, K) and *Begonia rex* 'President' (A, B, I, L). A: Longitudinal section of ovule showing megaspore mother cell. B, C: Linear and T-shaped megaspore tetrads with functional megaspore. Note formation of integumentary tapetum. D, E: Triads with functional megaspore. F–I: Embryo sac development. Note integumentary tapetum and hypostase. J: Degenerating ovule. K: Micropylar half of the embryo sac showing zygote and primary endosperm nuclei. L: Cellular endosperm with embryo. dol: degenerating ovule; emb: embryo; et: endothelium; hp: hypostase; t: tannin.

The development of the endosperm is ab initio nuclear. The primary endosperm nucleus divides earlier than the zygote (Fig. 2, K) and produces a large number of free nuclei which are distributed evenly throughout the embryo sac leaving a large central vacuole. Wall formation commences centripetally.

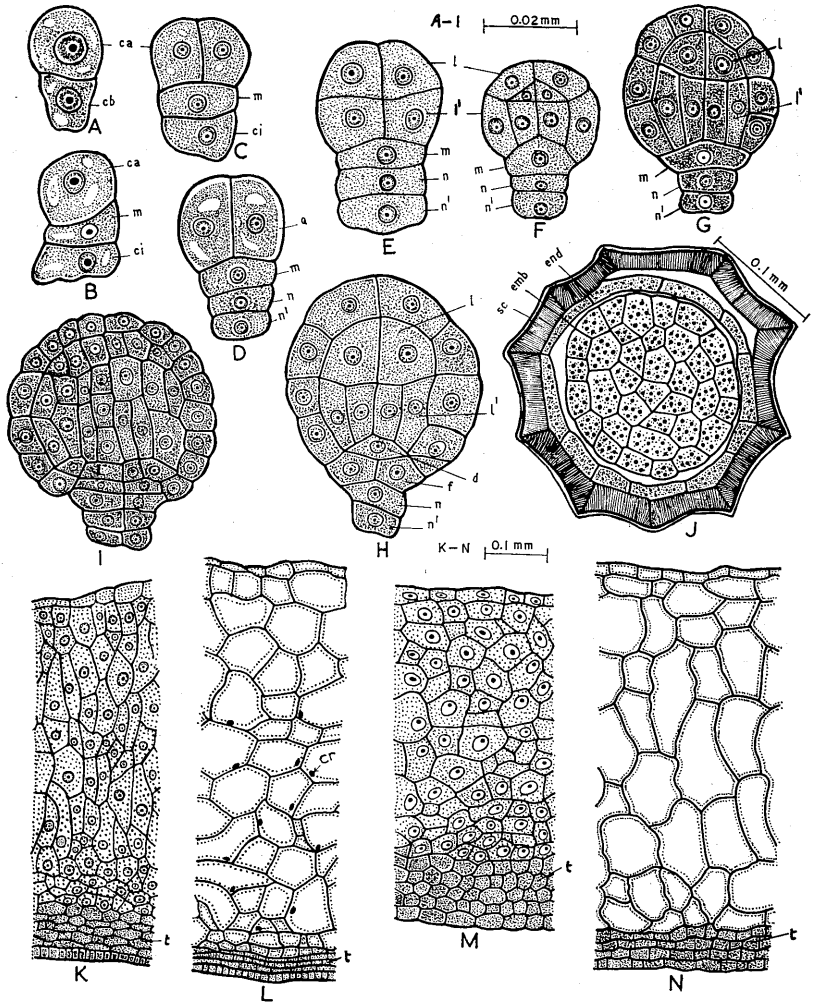

Fig. 3. *Begonia sulcata* (A, B, M, N) and *Begonia rex* 'President' (C–L). A–I: Stages in the development of embryo. J: Transverse section of mature seed. K–N: Stages in the development of fruit wall. emb: embryo; end: endosperm; sc: seed coat; t: tannin.

The endosperm is consumed by the growing embryo (Fig. 2, L). In the mature seed only one or two layers of endosperm persist around the embryo (Fig. 3, J).

Embryogeny. The zygote divides transversely to form the two-celled proembryo (Fig. 3, A). The basal cell *cb* undergoes a similar division resulting in cells *m* and *ci* (Fig. 3, B). The terminal cell *ca* next divides vertically producing two juxtaposed cells and thus a T-shaped proembryo is formed (Fig. 3, C). The two terminal cells of the tetrad soon undergo a vertical division at right angle to the first and organize the quadrants. A transverse division in *ci* produces two superposed cells *n* and *n'* (Fig. 3, D). The quadrant cells then undergo a transverse division forming two tiers of four cells each. The two tiers are designated as *l* and *l'* (Fig. 3, E). The tier *l* divides in all planes and gives rise to the cotyledons and stem tip. The tier *l'* undergo further divisions in all planes contribute to the formation of the hypocotyledonary region and a part of the root (Fig. 3, F–I). Meanwhile, in the cell *m* a transverse wall is laid down cutting off a lenticular cell towards apical side and watch glass-shaped cell towards the basal region. The lenticular cell is designated as *d* and the basal cell as *f*. The derivatives of *d* contribute to the remaining part of the root, and *f* together with the derivatives of the cell *ci* forms a small suspensor (Fig. 3, H, I).

The proembryo is a T-shaped tetrad and the terminal cell *ca* contributes to a major part of the embryo. Hypophyseal initial is differentiated and as the first division in the hypophyseal initial is vertical, the embryogeny in these species keys out to Alyssum the variation of Onagrad type. The cells of mature embryo are packed with oil globules as storage food materials (Fig. 3, J).

Fruit wall. At archesporium stage the number of wall layers is 17 in both the species and the cells of wall layers are parenchymatous. The interesting feature is that the inner epidermis and 4 or 5 layers adjoining it, contain tannin (Fig. 3, K, M). At megaspore mother cell stage the cells of the fruit wall become enlarged, remain thin-walled. After fertilization, the cells become enlarged considerably and by the time a globular embryo is formed, the cells of the fruit wall start loosing their content. At mature embryo stage the cells become greatly enlarged, irregularly arranged and remain parenchymatous (Fig. 3, L, N). At this stage calcium oxalate crystals are observed in the cells of the fruit wall of *B. rex* 'President' (Fig. 3, L).

Discussion Microsporangium, microsporogenesis, male gametophyte, mega-

sporangium, megasporogenesis, female gametophyte, abnormal behaviour of endothelium and hypostase, endosperm development, embryogeny and fruit wall structure and development in the present investigation are fit in well in the picture obtained from previous studies of embryology of the other species of the genus *Begonia* (Sandt 1921, Souèges 1939, Madulata 1950, Swamy & Parameswaran 1960, Devi & Naidu 1979, 1982, Devi *et al.* 1982, Naidu 1981, 1985, Naidu & Devi 1984). The development of the embryo, in the hitherto investigated species of the genus corresponds to the Lotus variation of Onagrad type. But in the present investigation it corresponds to the Alyssum variation of Onagrad type.

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ベゴニア属は広く栽培され，約 900 種が知られるが，胚発生の研究はほとんどない。そこで筆者はベゴニア属の 2 種 *Begonia sulcata* と *B. rex* 'President' について小胞子嚢・小胞子発生・雄性配偶体，子房・胚珠・大胞子発生・雌性配偶体，受精，内乳・胚形成，種皮について詳しい研究を行った。